Express Mail Cert. No.
EV 367 775 329 US
Serial No. 10/630,351

(11) (A) No. 1050899

(45) ISSUED 790320

(52) CLASS 182-13
C.R. CL.

(51) INT. CL. 2 B01D 13/00

(19) (CA) CANADIAN PATENT

(54) REVERSE OSMOSIS KIT FOR PRODUCING POTABLE WATER FROM SEA WATER

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Granted to Her Majesty in right of Canada as represented by the Minister of National Defence, Canada

(21) APPLICATION No. 233,376
(22) FILED 750813

(30) PRIORITY DATE

No. OF CLAIMS 7

DISTRIBUTED BY THE PATENT OFFICE, OTTAWA.
CCA-274 (2-74)

ABSTRACT OF THE DISCLOSURE

A method and apparatus for producing potable water from sea water which is particularly suitable for use in survival craft at sea. A reverse osmosis module is lowered from the survival craft to a depth of about 130 fathoms, at which depth the external pressure on the module is sufficient to cause substantially pure or at least potable water to permeate through the semi-permeable membrane of the reverse osmosis module into a ~~storage~~ collecting vessel. A pressure relief valve is provided on the water ~~storage~~ collecting vessel to prevent excess pressure build-up during recovery and an outlet ~~valve~~ means is also provided to remove the potable water when the apparatus is received in the survival craft.

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This invention relates to a method and apparatus for producing potable water from sea water. More particularly, this invention relates to a method and apparatus for emergency use in lifeboats.

In a survival situation at sea procurement of sufficient drinking water to enable survival for an extended period of time is of paramount importance. It has been estimated that each person aboard a lifeboat or other survival craft requires a minimum of one quart of fresh water per day if dehydration is to be avoided. For a 24-man boat this means storage of something in excess of 50 pounds of water, occupying about 1 cubic foot of space for each day of survival. For any reasonably lengthy survival time, therefore, stored water presents problems of weight and space utilization in a lifeboat or on an inflatable raft. The initial water supply may be supplemented by catching rain water but of course this is not a predictable or certain source and in any case is not available in areas of low or negligible rainfall. Evaporation techniques, based on solar stills are generally of limited effectiveness, the equipment required is bulky, relatively slow, extremely difficult to disassemble in adverse weather conditions, and of course only available for use under favourable weather conditions.

As an alternative to the foregoing, it has been suggested that devices operating upon the principle of reverse osmosis should be employed, and several devices in which sea water is pumped, under pressures of the order of 1000-1500 psi,

through a semi-permeable membrane have been described in the literature. One such device is described in "Manual Sea Water Demineralizer Development" - Cosmodyne Corporation, June, 1973, a report distributed by the National Technical Information Service of the United States Department of Commerce under AD-775,634. In such devices, manual pumps, with or without energy-recovery cycles, are provided so that survivors can pressurize a reverse osmosis vessel and produce sufficient potable water for survival needs. At the pressures required for reverse osmosis of sea water the pumps are necessarily of a fairly sophisticated nature and hence relatively expensive. Further, increased complexity usually leads to increased maintenance requirements, and in the survival situation it is unlikely that any maintenance or repairs at all can be carried out.

It is an object of the present invention, therefore, to provide a device for the production of potable water from sea water which avoids the use of manual pumps to provide the pressure necessary to carry out a reverse osmosis process of sea water.

Another object of this invention is to provide a novel method for the production of potable water by reverse osmosis from sea water.

Thus, by one aspect of this invention there is provided an apparatus for the production of potable water from sea water adapted to be lowered to depths of at least

130 fathoms below the surface of the sea and comprising: (a) potable water collecting means including: (i) a support member having a semipermeable membrane secured thereto and adapted to permit substantially potable water to permeate therethrough, at pressures corresponding to said depths below the surface, into potable water collecting chamber defined by said support member and said semipermeable membrane; and (ii) outlet means to recover said substantially potable water from said potable water collecting chamber; (b) potable water storage means including: (i) inlet means for receiving said potable water from said collecting means; (ii) outlet means to recover said potable water; and (iii) pressure relief valve means adapted to relieve air pressure therein and thereby maintain an internal pressure substantially equal to ambient external pressures during recovery of said apparatus from said depths; and (c) pressure relief and check valve means defining a one-way flow path for said potable water from said collecting means to said storage means, to prevent any backpressure, created during raising of the apparatus from said depths, from reaching and damaging the semi-permeable membrane.

By another aspect of this invention there is provided a method for producing potable water from sea water comprising lowering a reverse osmosis module to a depth of at least 130 fathoms below the surface of the sea, thereby creating an external pressure on a semipermeable membrane in said module sufficient to cause substantially potable water to permeate therethrough into a closed storage vessel, raising said module and simultaneously reducing pressure in said storage vessel to maintain an internal pressure substantially equal to ambient external pressure, and removing potable water from said storage vessel.

In order to eliminate the manual pumps of the prior art, an alternative reliable source of pressure to drive the reverse osmosis process must be provided. Clearly the one source of pressure which is always available in survival situations is the sea itself, provided only that it is deep enough. However, in shallow seas or on the continental shelf

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extended survival periods before rescue are most unlikely. Thus, if a reverse osmosis unit is lowered into the ocean depths, a sufficient pressure differential between one side of a semi-permeable membrane and the other may be developed so that reverse osmosis can be made to occur. Potable water passes through the membrane and is collected within. The osmosis unit can then be retrieved and the potable water collected. Calculations show that at pressures of approximately 24 atmospheres or 350 psi reverse osmosis of sea water can be effected. 24 atmospheres corresponds to a depth of approximately 130 fathoms (780 ft).

The invention will now be described in more detail with reference to the following examples and the drawings in which:

Fig. 1 is a front elevation of a first embodiment of the invention;

Fig. 2 is a sectional view of part of the first embodiment of the apparatus of the invention;

Fig. 3 is a sectional view of a second embodiment of the apparatus of the invention; and

Fig. 4 is a graph relating salinity with immersion at selected depths for different periods of time.

Referring firstly to Figs. 1 and 2, there is shown a cylindrical reverse osmosis module 10, having an outer casing 1, a sea water inlet 2 at one end thereof, a sea water outlet 2A at the other end thereof and a 1/3 psi NUPRO® stainless steel pressure relief and check valve 3 at the other end thereof. Preferably, but not essentially, the module 10

is of the Enro® UHP 98 type, which is approximately 22" long and 4" diameter, and provided with a spiral wrapped reverse osmosis membrane 4 on a grid support 5, thus forming an outer chamber 6 and an inner chamber 7 sealed therefrom. It will, of course, be appreciated that any suitable reverse osmosis membrane system may be employed. A 1000 cc stainless stee Whitney® cylindrical storage vessel 8 is mounted on the top of the reverse osmosis module 10 with any convenient external mounting framework 9, and in fluid communication with the interior chamber 7 of the module 10 via valve 3. A 10 psi air pressure relief valve 11 is provided at the top of vessel 8 and an outlet valve 12 for desalinated water at the bottom thereof. A lifting ring 13 is provided at the top of the framework 9 for attachment of a cable 14.

In operation, the entire apparatus, containing air at atmospheric pressure and weighing about 70 lbs., is lowered on cable 14, from a boat, to the desired depth, usually of the order of 130-150 fathoms and held at that depth for a period of time of the order of 3-7 minutes and then retrieved. Lowering and raising takes about 4 minutes. When the apparatus reaches the desired depth the external pressure in chamber 6 on the membrane 4 is sufficient to cause reverse osmosis therethrough and substantially pure water is forced to permeate through the membrane into the inner chamber 7. As potable water is produced, concentrated sea water escapes through outlet 2A in order to avoid excessive salt concentration build-up in the outer chamber 6. Check valve 3 opens and the water passes into storage vessel 8, compressing the

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air contained therein. Upon raising the apparatus, check valve 3 closes thereby preventing the purified water from returning to the module 10, and the pressure relief valve 11 opens to release sufficient air to maintain the pressure in the storage tank at a desired level above that of the surroundings. Also, check valve 3 prevents pressurized air in storage vessel 8 from applying back pressure on the membrane 4, and osmosis taking place during recovery. Upon recovery into the boat the desalinated water can be removed by opening outlet valve 12 and the apparatus prepared for another purification cycle.

Example 1

A device as described hereinabove with reference to Figures 1 and 2 was prepared and tested at various depths in Haro Strait off Vancouver Island, B. C., Canada, for periods of time varying between 1.5 and 7 minutes at depth. The natural salinity in this area is about 2.7-3.0%. The depth of water was measured by means of a type 8 depth gauge manufactured by Tsurami Saki Kosakusho Co. Ltd. and corrected for slope of cable. As seen from Fig. 4, which summarizes the results, the relationship between salinity of water produced and maximum depth of immersion appears to be linear when the device was maintained at maximum depth for 3 minutes and raised and lowered at constant speed (approximately 4 minutes). It was also found that by leaving the device at maximum depth for 7 minutes an improved, lower salinity, product was obtained.

It will, of course, be appreciated that many modifications to the apparatus described hereinabove are possible

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and within the scope and purview of the present invention. For example, as the purity of the water produced improved with depth the apparatus should be sized so that as much water as possible is collected at maximum depth, and as little as possible during raising and lowering. For the same reason, sea water inlet 2 and outlet 2A may be provided with a pressure operated valve to accurately regulate water intake to the desired pressure levels only.

A simplified version of the device of Figures 1 and 2 is shown in Figure 3 and represents an inexpensive embodiment particularly suitable for use on small survival craft where space is very limited and the amount of water required is smaller. In Fig. 3, the reverse osmosis module and the water storage vessel are combined in the form of a cylindrical sintered porous vessel 20 with solid non-porous ends 21 and 22 and weighing only 4-6 lbs. in air and 2-4 lbs. in water when empty. Preferably, the vessel 20 is a sintered bronze or stainless steel material and is conveniently 3" in diameter and 8" long. The porous walls of vessel 20 are covered with a semipermeable membrane 23, preferably cellulose diacetate-cellulose triacetate which is either cast or attached to the outer surface, thereby forming a reverse osmosis module similar to that of Figure 1 but without the casing 1. Non-porous end 22 is provided with a 1/3 psi pressure relief valve 24, an outlet valve 25, and a lifting ring 26. The principle of operation is as before in that as the unit is lowered into the sea, the external pressure rises until, at a pressure of about 24 atmospheres (130 fathoms depth) reverse

osmosis takes place and desalinated water permeates through the membrane 23 and porous walls 20 into the vessel. When three-quarters full of water, the unit only weighs 6-8 lbs. in air and 4-6 lbs. in water so that raising and lowering upon a thin steel wire, such as that used by sports fishermen presents little difficulty. Upon recovery, as the unit is raised, the excess trapped air pressure in the vessel escapes through relief valve 24 thereby preventing the internal pressure from rising significantly above the surrounding external pressure and forcing the membrane 23 off the surface of the vessel 20. Upon recovery at the survival craft, the potable water is removed via valve 25 and the unit is then ready for return to the sea for further recovery.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An apparatus for the production of potable water from sea water adapted to be lowered to depths of at least 130 fathoms below the surface of the sea and comprising:

(a) potable water collecting means including: (i) a support member having a semipermeable membrane secured thereto and adapted to permit substantially potable water to permeate therethrough, at pressures corresponding to said depths below the surface, into potable water collecting chamber defined by said support member and said semipermeable membrane; and (ii) outlet means to recover said substantially potable water from said potable water collecting chamber;

(b) potable water storage means including: (i) inlet means for receiving said potable water from said collecting means; (ii) outlet means to recover said potable water; and (iii) pressure relief valve means adapted to relieve air pressure therein and thereby maintain an internal pressure substantially equal to ambient external pressures during recovery of said apparatus from said depths; and

(c) pressure relief and check valve means defining a one-way flow path for said potable water from said collecting means to said storage means, to prevent any backpressure, created during raising of the apparatus from said depths, from reaching and damaging the semi-permeable membrane.

2. An apparatus for the production of potable water from sea water adapted to be lowered to depths of at least 130 fathoms below the surface of the sea and comprising:

(a) a potable water collecting means including: (i) an outer casing; (ii) a porous support member secured within said outer casing thereby defining an inner and outer chamber; (iii) a sea water inlet and outlet in said outer chamber; and (iv) a semipermeable membrane mounted on said support member

and adapted to allow substantially potable water to permeate therethrough into said inner chamber at pressures corresponding to said depths; (v) outlet means to recover said substantially potable water from said inner chamber;

(b) a potable water storage means including: (i) inlet means for receiving said potable water from said collecting means; (ii) outlet means to recover said potable water; and (iii) pressure relief valve means adapted to relieve air pressure therein and thereby maintain an internal pressure substantially equal to ambient external pressures during recovery of said apparatus from said depths; and

(c) pressure relief and check valve means defining a one-way flow path for said potable water from said inner chamber to said storage means, to prevent any back-pressure, created during raising of the apparatus from said depths, from reaching and damaging the semi-permeable membrane.

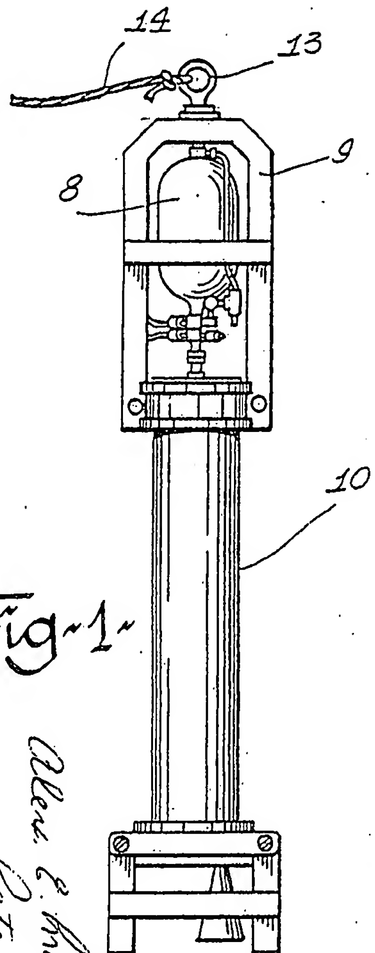
3. An apparatus as defined in claim 1 or 2, including an external mounting frame adapted for attachment to cable means for raising and lowering said apparatus.

4. An apparatus as defined in claim 1 or 2, wherein said semipermeable membrane is cellulose diacetate-cellulose triacetate.

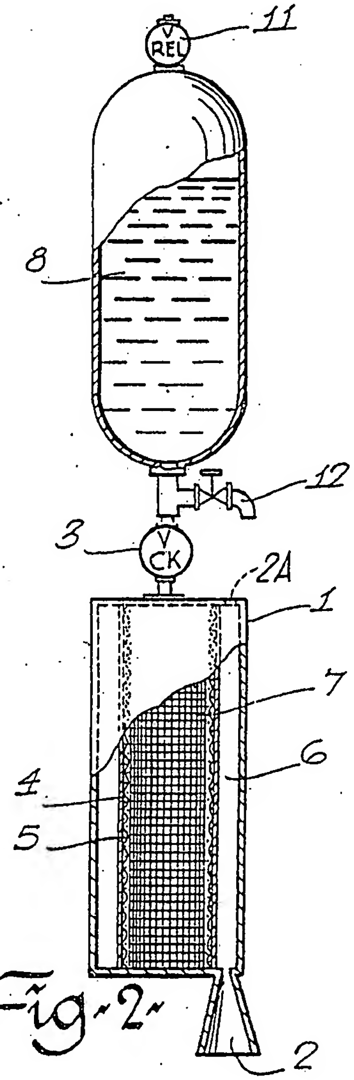
5. An apparatus as defined in claim 1 or 2, wherein said pressure relief and check valve means is a 1/3 psi pressure relief and check valve.

6. An apparatus as defined in claim 1 or 2, wherein said pressure relief valve means is a 10 psi pressure relief valve.

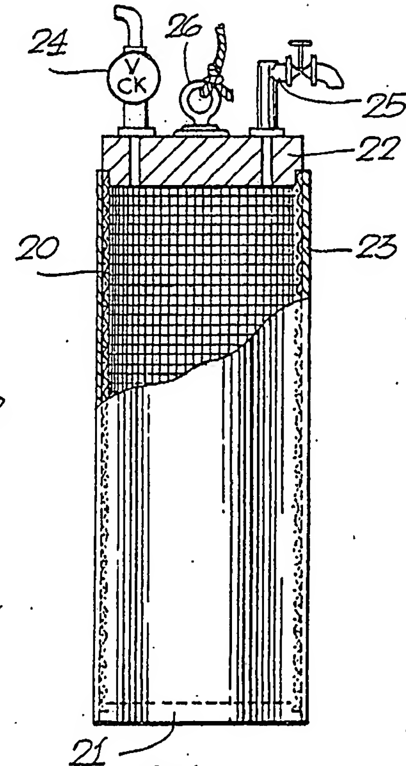
7. An apparatus as defined in claim 1 or 2, wherein said semipermeable membrane is mounted externally of said support member.



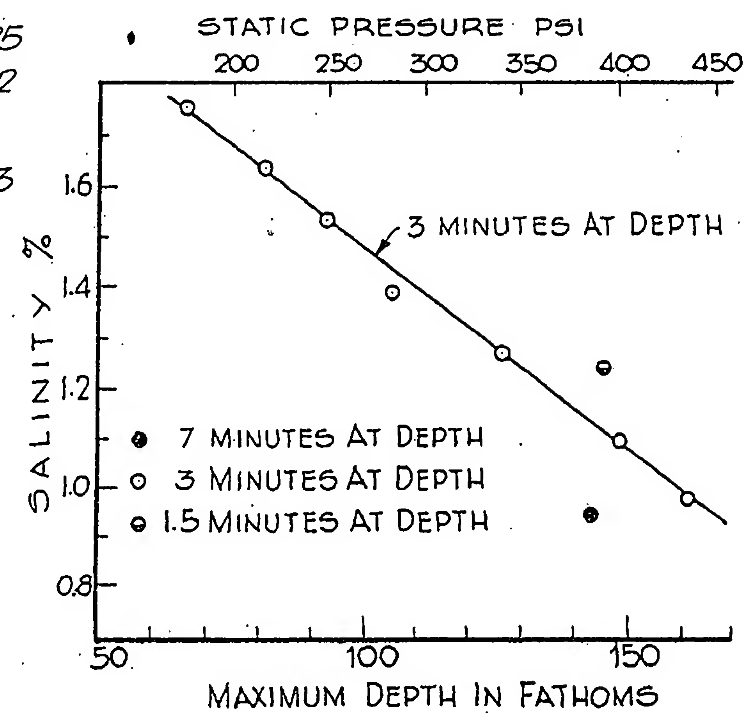
~Fig~1~



~Fig~2~



~Fig~3~



~Fig~4~

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